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Response of the Pulp and Paper Industry in the Great Lakes Basin to Pollution Abatement Programs

Water Quality Programs Committee. Pulp and Paper Point Sources Task Force

Report to the
Great Lakes Water Quality Board

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by the

Pulp and Paper Point Sources Task Force

of the Water Quality Programs Committee

October 1981

Preface

The Pulp and Paper Task Force of the Water Quality Programs Committee is pleased to submit this report to the Great Lakes Water Quality Board. It includes an overview of the progress made by the pulp and paper industry to reduce its discharges of deleterious substances into the Great Lakes.

The Great Lakes Water Quality Board has reviewed and approved the Task Force's report for publication.

Mention of trade names or names of commercial organizations in this report does not constitute endorsement by the International Joint Commission or any other government agency.

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Preamble

Historically the pulp and paper industry has been a major source of water pollution. Over the years, regulatory agencies in the Great Lakes Basin have made considerable effort to have the mills in the region improve their effluents. In the early '70's new laws and regulations converted these efforts into more definitive requirements for abatement programs designed to protect the environment and the beneficial uses of the Great Lakes waters.

The 1972 and 1978 Great Lakes Water Quality Agreements encouraged greater coordination of pollution control efforts to achieve international objectives for water quality. One of the tasks of the Great Lakes Water Quality Board is to report regularly on the progress of industry in controlling pollution. In 1977 a subcommittee of the Board prepared a special report on three major polluting industries, one of which was pulp and paper (Appendix C, Remedial Programs Subcommittee Report to the Great Lakes Water Quality Board, IJC, 1977). In 1981 the Water Quality Programs Committee established a Pulp and Paper Task Force to review the implementation and results of regulatory programs. The Task Force used several criteria to evaluate progress, including total suspended solids (TSS), biochemical oxygen demand (BOD), the fish toxicity test (as a bioassay indicator), taste and odour, nutrients, and the presence of persistent toxic substances.

This report describes the findings of the Task Force regarding effluent quality improvement programs and monitoring protocols (their effectiveness and quality assurance), and trends of pollutants discharged. In summary, the Task Force concludes that the industry has made substantial progress in meeting effluent limitations and must continue its pollution abatement programs in a timely fashion to meet the requirements of the Agreement. It also believes that technological innovations as well as resource economics will result in continuing improvement.

In this report, the findings and recommendations of the Task Force are presented, focusing on changes which the industry could make to further reduce conventional pollutants and potentially toxic substances.

Conclusions

The Task Force reviewed the progress made by the pulp and paper industry to reduce its pollutant discharges in response to pollution abatement programs and concluded that:

- Significant improvement in the quality of wastewaters being discharged from Canadian and United States mills into the Great Lakes System has been observed. Rehabilitation of the local aquatic environment has been documented elsewhere. The rate and degree of improvement depends not only on the extent of past damage to these areas before the mills improved their effluent quality, but also on the physical, hydrological, and general environmental factors at these locations.

- It is possible to detect and assess the nearshore effects that can be attributed to a single discharger. However, pulp and paper mills are only one of the industrial operations polluting the waters of the Great Lakes. To measure or estimate the improvement in the quality of open lake waters which is directly attributable to pollution abatement activities by this industry alone is difficult.

- Despite a relatively constant increase in pulp and paper production over the past 13 years, there has been a significant decrease in the discharge of conventional pollutants by this industry in both countries.

- All mills undertake self-monitoring programs on the effluents discharged into the Great Lakes. At the same time, all jurisdictions undertake audit/quality assurance programs to ensure the quality of the data reported. Where violations are encountered, the appropriate enforcement actions are taken.

- All jurisdictions are empowered to take the appropriate enforcement actions if violations of permit or control order requirements are encountered.

- Comparison of aggregate data on pollution loads and pulp and paper production between Canada and the United States is misleading because of differences in the structure of the industry in the two countries. In Canada the industry is characterized by more pulping operations whereas in the United States paper mill operations predominate.

- In the 1970's the two nations adopted different effluent abatement strategies. However, there has been a continual narrowing of these differences because the objectives of the abatement programs are becoming similar. In the case of toxic substances, both Canada and the United States are following similar strategies.

- New technology, energy conservation, raw materials, and labour costs are beginning to exert a significant positive impact on raw waste discharges because of the overall necessity to optimize operations.

- Past and ongoing support programs, such as those for research and development, have contributed significantly to the improvement in effluent quality and to the overall knowledge of cause and effect from such effluents.

- There are 44 mills discharging all their wastewaters into municipal sewer systems. In addition, some other mills discharge a portion of their wastewaters into municipal systems. The Task Force did not attempt to assess the impacts of such discharges on the Great Lakes because it is virtually impossible to distinguish and characterize such effluents after they have been mixed with other wastewaters and subjected to treatment at municipal facilities.

- Phosphorus and ammonia are usually added to biological treatment systems to assist in the process of biodegradation of organics in the effluent. The final treated effluent is usually low in these nutrients unless overdosing initially occurred.

- PCBs are associated with the recycling of certain types of waste paper. The removal efficiency in effluents contaminated with PCBs is related to the removal of suspended solids.

Recommendations

1. Although the pulp and paper industry has made considerable progress in reducing the loadings of BOD and TSS into the Great Lakes, further improvements are necessary to meet the Agreement objectives. In addition, attention should be focused on identification and reduction or removal of toxic pollutants, particularly halogenated organics and other substances which are persistent and/or bioaccumulate.

2. Problem mills should be identified by means of biomonitoring techniques and chemical analyses of effluent and environmental samples.

3. The pulp and paper industry should discontinue the use of trichlorophenol and pentachlorophenol as slimicides.

4. The industry should be encouraged to:

   - use chlorine dioxide instead of chlorine in the bleaching process;

   - improve washing efficiency of unbleached pulp in order to minimize carry-over of dissolved organics; and

   - effect other appropriate and feasible internal adjustments as outlined under the new technology section of this report in order to reduce production of chlorinated organics.

5. Pulp and paper mill effluents should not be toxic to aquatic life.

6. Where PCBs are discovered in the effluent, the regulatory agency should limit the suspended solids on which PCBs are usually adsorbed to the lowest level consistent with available technology.

7. Overdosing biological treatment systems with nutrients, such as phosphorus and ammonia, should be avoided.

8. Research on the nature of pollutants generated during the manufacturing of pulp and paper, the treatment of those pollutants, and their effects on the receiving waters should be continued.

Pollution Abatement Programs in Canada

The 1978 Water Quality Agreement requires the Governments of Canada and the United States, in cooperation with state and provincial governments, to take additional actions to control boundary waters pollution. The actions include or depend upon monitoring activities to determine whether "general" and "specific" water quality objectives outlined in the Agreement are achieved. The 1978 Agreement emphasizes persistent toxic substances and requires the virtual elimination of their discharge into the Great Lakes system.

In Canada responsibility for environmental protection is shared between the federal and provincial governments. The federal government develops national baseline effluent and emission requirements and guidelines for specific industrial groups. The provinces enforce either the federal requirements as a minimum or more stringent requirements, as necessary, on a site specific basis. The following describes the federal and provincial regulatory requirements in more detail.

FEDERAL PROGRAMS

The Fisheries Act and the Environmental Contaminants Act are the principal laws under which the federal government implements the programs that respond to the requirements of the Agreement.

Pulp and Paper Effluent Regulations, issued under the Canada Fisheries Act, cite three parameters as being deleterious to fish: TSS, BOD_5, and toxicity. Toxicity is defined in the pulp and paper regulations as a pass/fail test whereby 80% of the fish held in a 65% effluent concentration must survive for 96 hours, unless there is a failure in the control (dilution water) test as well. If less than 80% of the fish survive, the effluent is deemed to have failed the test. Under federal regulations, BOD_5 and TSS are related to the amount of production from a particular mill operation. The aggregate of the allowance from all the mill process components is used to arrive at the allowable daily BOD_5 and TSS discharges.

From the time that the regulations came into force in 1971 until March 31, 1979, the federal government developed a special research program called the Cooperative Pollution Abatement Research Program (CPAR), which provided funds to conduct research into methods of abating pollution from the pulp and paper industry. The CPAR proposals were received once a year and assessed at special program meetings, where proposals were funded or rejected according to their merits. While the major portion of the funding was allocated for water pollution abatement projects, about 30% out of a total of $1-1.5 million per year was allocated for air pollution. This research was primarily directed toward reducing the quantities of the three deleterious materials and assessing their impact on the environment. Also assessed were the methodology for measuring BOD with short term tests, and various modifications and evaluations of the toxicity test.

As a logical extension of this research effort, the CPAR program in its later years began to address the issue of toxic substances. A major research program was directed at determining which of the process streams constituting the pulp and paper effluents from the various types of mills, were likely to contain contaminants which warranted further investigation. In summary, this project revealed that the major pollutants appear to be concentrated in the effluents from the kraft bleaching and to a lesser degree from the sulphite bleaching. Subsequent to this study, a number of research studies were undertaken to determine which of the chemical components of pulp and paper effluents might be the most logical candidates for assessment. As would be expected from the nature of the compounds which are in these effluents, and from the previous history of such compounds, a number of chlorinated organics were identified as causing positive Ames tests and chromosome aberration test responses. A number of these projects were conducted under the direction of the Department of National Health and Welfare.

ONTARIO PROGRAMS

The Ontario Water Resources Act and the Environmental Protection Act provide legislative authority for the pollution abatement programs of the Province. The legislation prohibits the discharge of pollutants that adversely affect the quality of air, water, and land. Enforceable legal requirements subject to appeal include Control Orders, Requirements, and Directions or Program Approvals.

Industrial sources are required to submit a satisfactory engineering design to obtain a Certificate of Approval from the Ministry of the Environment for pollution control measures including construction of related facilities. Schedules of program implemention, limitations on operations, including legally enforceable effluent requirements, may be included in the Certificate.

Prior to setting any requirements, the Ministry studies and evaluates the effects of pulp and paper mill discharges on water quality. Provincial Water Quality Objectives are outlined in the publication "Water Management - Goals, Policies, Objectives and Implementation Procedures of the Ministry of the Environment." These objectives are a set of narrative and numerical criteria designed for the protection of aquatic life and recreation. Where water quality objectives are exceeded, the Ministry requires effluent improvement. The establishment of effluent requirements takes into account the toxicity provisions of the federal Fisheries Act.

The scope of Ministry requirements may include in-mill changes as well as conventional end-of-the pipe treatment systems. In-mill changes are the best method for decreasing pollution discharges and are often accompanied by increased product yield or a decreased usage of chemicals or energy. When a section of a mill is modernized, the Ministry insists that new mill technology be used, that the process effluent cycle be "closed", or that the discharge be kept to a minimum through internal recycling.

Water pollutants of concern in pulp and paper wastes are: TSS, BOD, fish toxicants, compounds that impart taste and odour to fish and water, and colour.

The pollutants in the mill effluent reflect the type of process used; the quantity of the effluent generally reflects the age of the equipment. For old pulp mill operations, millions of gallons of effluent are produced making it difficult and expensive to treat properly. Paper making effluents, however, can be more readily controlled and discharged into municipal treatment systems. On the other hand, chemical pulping mills are complex process operations and their effluent contains a myriad of chemical compounds which are difficult to remove.

In Ontario there are 22 locations where mills discharge directly into the Great Lakes Basin. At these locations various processes are used:

- 13 chemical operations producing virgin pulp;
- 10 mechanical operations producing virgin pulp;
- 1 deinking operation; and
- 22 paper making mills.

A Control Order addresses site specific problems at a given mill. It describes the remedial action and the time period, generally 2-5 years, required to complete the abatement measures. If the need arises, Control Orders may be revised. Of the 22 mill locations in 1981, twelve Control Orders are in place; three are under development, two are satisfactory, while the remaining five are under study.

Enforceable measures, such as Control Orders, address water, air, and solid-waste improvements since very often these problems are interrelated. For example, to bring kraft mill air emissions under control, a new recovery furnace system may have to be constructed. The expanded capacity of such a recovery system will permit spill recycling or process closure and reduced effluent discharge. About one-third of the TSS and BOD_5 discharged from a kraft mill results from spills.

When specific compounds are identified as being problems, corrective action is required. For example, zinc hydrosulfite was used as a brightener in newsprint production. In the mid-1970's the industry was requested to reduce the zinc content of effluents. They voluntarily switched to sodium hydrosulfite and as a result zinc in effluents was reduced to trace levels.

Similarly, industry was advised to stop using chlorophenol compounds as a slimicide. As a result, by the end of 1978 pentachlorophenol and trichlorophenol were phased out in Ontario mills.

OTHER PROGRAMS

The Ministry supports the development of innovative unproven technology which reduces pollution. In-mill innovation may also improve productivity and product quality. Where a company is prepared to develop such technology, the Ministry will incorporate this approach into a legal requirement. For example, the Ministry agreed to include the installation of a closed process recycle for a new kraft mill in the Requirement and Direction issued to the Great Lakes Forest Products in June 1977. After a review of the technical difficulties associated with the installation of this system and other alternative abatement measures, a new Control Order was issued in 1981 to incorporate the appropriate solutions for the closed-cycle system.

As a cooperative effort with the federal government, the Ontario Ministry of the Environment assesses various effluents under the toxicity provisions of the federal Fisheries Act. The toxicity tests are scheduled to follow mill effluent improvement.

Laboratory capacity has been expanded to provide analytical services for toxic and hazardous compounds. All industrial effluents are being surveyed and evaluated by the Ames test. The results of this testing program are not available yet. Meanwhile, the Trace Organics Section is developing an accurate phenols analysis for the pulp and paper industry. The test method normally used for phenols (the 4-aminoantipyrine method) is inaccurate when used for pulp and paper effluent, as lignin compounds interfere with the analysis.

The Ministry involves local communities by soliciting views on pollution abatement proposals at public meetings. The Ministry describes the problem areas while the company explains the proposed abatement measures. Community input may change priorities. To date, all communities have preferred additional in-mill changes before building any secondary treatment system.

CANADA-ONTARIO FACILITIES IMPROVEMENT PROGRAM

In 1978, as a result of several studies of the industry, the governments of Ontario and Canada became seriously concerned about the low productivity of the pulp and paper industry. To improve productivity, grants were given to each company that committed itself to extensive modernization under the Pulp and Paper Facilities Improvement Program. This program was well received by the companies in the Great Lakes Basin. Within a five year period the following achievements are expected:

- pulp yield will be increased 15% by installing new pulping processes;
- energy usage will be decreased;
- more self-generated energy will be produced from residue burners and new turbines;
- product quality will be improved;
- manpower will be more effectively used;
- waste loads in effluents, air emissions, and solid wastes will be reduced; and
- new recovery systems in kraft mills will permit more recycling.

Effluent Limitations in Canada

The federal Pulp and Paper Regulations prescribe the amount of deleterious material which can be discharged from any mill, based on its product and production rate (Appendix I). The Regulations also take into account the type of process and whether the mill is new or old.

The current focus is on assessment of the components of pulp and paper effluents, including additives such as slimicides, other pesticides, retention aids, dyes, pigments, and fillers. These substances are being assessed under various parts of the Environmental Contaminants Act. The major emphasis is on determining which components of pulp and paper effluents are to be considered persistent toxic substances. There is an indication that the chlorinated organics produced by the industry can create certain sublethal responses in test organisms and tissue cultures. Furthermore, a number of these components in concentrations noted in raw effluent discharges are also known to be lethal to fish. It is difficult to assess the effects on the environment after the effluent, either treated or untreated, reaches the surface waters and becomes diluted. Attempts have been made to assess other deleterious effects such as taste, odour, and colour (which affects primary productivity) but test conditions have been variable and do not necessarily represent the dynamic natural situation. The components of the effluents which seem to be creating sublethal responses in the Ames and chromosome aberration tests, also appear to be relatively unstable. Furthermore, these latter tests may not be of significance in toxic chemicals assessment. They are used now only as screening tests. The difficult question is whether there is a necessity to regulate such components if they have a limited life span, and what the consequences are if they are not regulated.

An assessment of the current limits for pulp and paper mill discharges under the federal regulations appears to indicate that a new mill could reach levels of control better than those stipulated in the current regulations, merely through proper design and close control over the operation, particularly in the area of spill control. Thus, in the future, it is likely that limits on pulp and paper effluent discharges in Canada will focus on toxic substances in the effluent.

Ontario's pulp and paper pollution abatement program addresses the compounds identified as pollutants in Ontario's Water Management Goals, Policies and Objectives. These objectives are usually more restrictive than the federal requirements, particularly for TSS and BOD_5. Studies of chlorinated organics in the wastewaters from kraft mill bleacheries are ongoing. Corrective actions will probably be required. The effects of nutrients in terms of undesirable aquatic life are also under review. The effects of pulp and paper effluent components upon fish, in addition to acute toxicity, are of concern and may require selective abatement measures.

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Discharge Trends in Canada

A list of pulp and paper mills that discharge all or part of their process wastewater directly into the Great Lakes is included in Appendix IV. Appendix IV also includes the 1980 average daily loadings of TSS and BOD for these mills. Appendix V lists those mills that discharge their process wastewaters into municipal sewer systems also known as the Publicly-Owned Wastewater Treatment Works (POTW). No loadings are reported for those mills because their effluents are subjected to treatment.

Discharge trends for TSS and BOD_5 from the Ontario mills that discharged directly into the Great Lakes during the years 1967, 1973, 1977, and 1980 are included in Table 1. This table also includes production figures of pulp and paper for the same years. While all mills produce saleable products, a pulping mill may produce pulp which is then converted into paper at the same location. This type of mill is usually considered as being both a pulp and paper mill. To avoid crediting such a mill with double its actual production rate, the figures reported in Table 1 represent saleable products.

TABLE 1. ONTARIO DISCHARGE TRENDS
(All Data in Megagrams Per Day)

Year	1967	1973	1977	1980
TSS	375.0	126.4	101.3	95.5
BOD	610.3	469.2	387.8	346.7
Production*	7,354	7,973	8,219	9,119

*Saleable production - pulp and paper totals.

As the data in Table 1 indicate, TSS and BOD_5 discharges from Ontario mills have decreased since 1967. While TSS and BOD_5 reduction between 1967 and 1980 amounted to 74% and 43%, respectively, pulp and paper production increased by 24%. In 1984 the expected discharges of TSS and BOD_5 will be 71.3 and 244.0 megagrams per day, respectively, while saleable production will increase to 10,745 megagrams per day. These projected values are based on the legal requirements of existing Control Orders. Since the mid-1970's twenty-two Ontario mills have been discharging directly into the Great Lakes. Some mills, however, may include more than one type of pulping operation at the same location. This report considers such operations as one mill; some past reports did not. Hence, there may be a discrepancy between the number of mills included in this report and the number reported previously.

As indicated above, the raw waste loads depend on the manufacturing process used, the type of product made, and the age of the mill. Chemical pulping results in the most complex and the heaviest pollution loading of mill wastewaters. Fortunately, the economics of the most versatile and widely used chemical pulping process, the kraft, are a driving force for process closure. Although the yield of kraft pulp is 45 to 55% of the log, efficient closed-cycle recovery processes can produce effluents of better quality than those of secondary treatment facilities. The second chemical pulping process, the sulphite, also results in a heavy pollution load. The recovery processes for this type of mill are not as fully developed as for the kraft mill. In Canada there is a move to convert small sulphite operations into new mechanical processes, which will still include some type of chemical treatment in the pulping process. The reduction in pollution from such conversion could amount to 175 kilograms of BOD_5 per megagram of saleable product. For a typical 228 megagrams per day mill, this is a reduction of approximately 40 megagrams of BOD_5 per day. Researchers are now investigating the feasibility of closed-cycle systems in mills employing new chemical-mechanical processes. Meanwhile, new analytical methods for assessing the efficiency of innovative pulp washers and concentrators are being developed in laboratories.

Pollution Abatement Programs in the United States

FEDERAL PROGRAMS

In the United States, pulp and paper wastewater pollution abatement programs are administered through the Federal Water Pollution Control Act (FWPCA). The 1972 amendments to this Act required that the U.S. Environmental Protection Agency (U.S. EPA) develop national effluent limitations (guidelines) for the various industrial categories. Under this program each direct discharger must apply for and obtain a National Pollutant Discharge Elimination System (NPDES) permit from either the federal government or the state in which the discharge occurred. The federal government can grant the authority to issue NPDES permits to the individual states. The NPDES permits, which are issued for a period not to exceed 5 years, include effluent limitations specifying the quantity and quality of the pollutants that can be discharged. They also contain self-monitoring requirements to insure compliance with these effluent limitations, and where necessary, a schedule of compliance setting forth dates for construction of facilities or other means to achieve the required effluent limitations.

The Act envisioned a two step process for reducing the levels of pollutants being discharged. By July 1, 1977 dischargers were to have achieved the level of pollution reduction obtainable through the use of Best Practicable Control Technology Currently Available (BPT). By July 1, 1983 (later revised to July 1, 1984) they were to have attained the level that could be achieved through the use of Best Available Technology Economically Achievable (BAT).

In December 1977 the FWPCA was amended again and is now commonly called the Clean Water Act. The 1977 Act's major emphasis is on the control of toxic pollutants. A major change was the classifying of industrial pollutants into three categories:

Conventional - BOD, suspended solids, fecal coliform, and pH were originally designated in the Act, and oil and grease were added later by the U.S. EPA.

Toxic - Sixty-five toxic substances and categories were agreed upon in a Court settlement between the U.S. EPA and the Natural Resources Defense Council in 1976. This list was refined to 129 specific pollutants. The U.S. EPA may add or delete pollutants from the list after public notification and comment. (See Appendix III)

Nonconventional - Any pollutant not designated conventional or toxic.

By July 1, 1984 industrial dischargers must achieve effluent limitations equivalent to Best Conventional Pollutant Control Technology (BCT) for those pollutants designated as conventional and BAT for toxic and nonconventional pollutants.

The national guidelines are the minimum requirements. More restrictive limits can be imposed, if necessary, to ensure that the quality of the receiving water is not degraded below its designated standard, or if the state has more stringent effluent standards.

WISCONSIN PROGRAMS

Wisconsin began its efforts to control water pollution from its pulp and paper industry as early as 1925 through the joint efforts of the Wisconsin State Board of Health and Committee on Water Pollution. By the late 1940's Wisconsin was conducting regular four year surveys and publishing a summary report of its findings. On the basis of these reports, orders were issued to industries requiring the implementation of certain best management practices that would reduce pollutant loadings and improve stream quality. By the late 1950's and early 1960's technology included, but was not necessarily limited to, internal save-alls for suspended solids recovery with evaporation and burn and/or by-product recovery for spent sulphite liquors, and instream aeration and/or retention of strong wastes during warm weather low flow periods.

From 1968 to 1970 stream surveys were completed on the major pulp and paper mill receiving waters which included lakes Michigan and Superior. Subsequent orders were issued requiring additional pollutant reductions by means of primary treatment for paper mill wastewaters and secondary treatment for pulp mill wastewaters, or combinations thereof. With the passage of the FWPCA Amendments of 1972, fulfilling these orders slowed down until December 1974 when the NPDES permits were finally issued by the state. The new permits incorporated the original ordered limitations as initial or interim goals and required final BPT limitations to be met no later than July 1, 1977. All but four of the mills discharging into the Great Lakes met the deadline, and the last of those facilities completed its treatment system and complied with the limits in late 1978.

Wisconsin has continued since then to maintain a rigorous compliance monitoring/enforcement program to ensure that the BPT effluent limitations are met and significant violations are eliminated.

It has been determined, however, that the present BPT allowances in many cases will not ensure that applicable water quality standards relating to dissolved oxygen will be maintained in the receiving waters. The state, therefore, has spent considerable time and resources modeling these receiving waters for various reaches of the river below the dischargers and developing Waste Load Allocations (WLAs). These WLAs, when promulgated in code form, will be proposed for incorporation into the dischargers' permits to further restrict BOD_5 discharges during critical periods when river temperatures are high and stream flows low.

In addition, the state has several other ongoing programs directed primarily at the determination and identification of necessary and applicable controls of toxic and nonconventional pollutants from the pulp and paper industry. Brief summaries of three of these programs are presented in the following paragraphs.

TOXIC EFFLUENT STUDY REQUIREMENTS

Towards the end of 1978 when all of Wisconsin's major industrial discharger permits were expiring, the Wisconsin Department of Natural Resources (DNR) decided to incorporate a schedule of compliance into the reissued permit for "Investigating the Nature and Quantities of Toxic and Nonconventional Pollutants" that might be present in the discharges. In addition to analyzing for these pollutants, the dischargers must also determine which processes add or generate these pollutants and the concentrations present in the influent and effluent of the existing wastewater treatment facility.

DNR is seeking more information from these and other facilities known to have discharges containing toxic pollutants, by requiring that such dischargers apply for their next permits no later than December 31, 1981, and that they use the new EPA Consolidated Application forms covering 129 priority (toxic) pollutants plus many other toxic and hazardous substances. DNR will use this information to determine control requirements per toxic pollutants in the next round of permit issuances/reissuances.

BIOASSAY PROGRAM

In 1978 an ongoing effluent bioassay program was initiated by Wisconsin DNR to learn more about the acute toxicity of as many effluents as possible. Two municipalities, including nine pulp and paper mills, were studied.

The researchers recognized that chronic (long-term) toxicity potentially would be more of a problem than acute (short-term) toxicity. However, acute toxicity testing was initiated because of the lack of financial and manpower resources, and because acute toxicity data were not available.

FOX RIVER INVESTIGATION

Another major study was completed in 1978 under contract with the U.S. EPA (Report No. EPA 905/3-78-004) entitled "Investigation of Chlorinated and Non-chlorinated Compounds in the Lower Fox River Watershed." This study resulted from increasing concern over potentially toxic organic compounds entering the environment, primarily from the pulp and/or paper mills on the 64 kilometer length of the Lower Fox River. Extensive sampling of river water, sludge deposits, effluents, fish, and clams resulted in the identification of 105 compounds, 20 of which are on the EPA Priority Pollutant List. PCBs, found in some of the samples from each group tested, were of particular importance due to their rapid bioaccumulation characteristics. Values ranging from 0.5 to 90 mg/kg were found in the fillet tissue. State authorities are continuing the investigation.

MICHIGAN PROGRAMS

Michigan has over 100,500 square kilometers (38,800 square miles) of Great Lakes within its boundaries. All pulp and paper mills in this State discharge into the Great Lakes Basin. Twenty Michigan mills discharge all or part of their wastewaters directly into natural waters; another 12 discharge into municipal systems for the treatment of their wastewaters. Recently an NPDES permit was issued for the proposed discharges from a 748 megagrams-per-day bleached kraft pulp mill to be constructed at Quinnesec, Michigan, and to be in operation in 1984.

The Michigan Water Resources Commission has the authority to protect the water resources of the State, including the Great Lakes. In the late 1960's identified problem industrial dischargers were given the opportunity to meet certain standards voluntarily. Failure to proceed in a timely manner was cause for statutory proceedings against the discharger and the issuance of Orders. It was the State's intent to abate such waste problems by June 1, 1970.

The enactment of the 1972 Amendments to the FWPCA required the mills to achieve effluent limitations reflecting either BPT or more stringent requirements, if needed, to meet applicable State Water Quality Standards by July 1, 1977.

Michigan was one of the first states to receive authority from the U.S. EPA to issue NPDES permits. By the required date of July 1, 1977 only two mills were not in compliance with the effluent limitation requirements of their NPDES permits.

The Michigan Department of Natural Resources has developed the Critical Materials Register Program to provide the foundation for the overall Toxic and Hazardous Material Management Program. The Critical Materials Register (CMR) is a list of toxic substances of high environmental concern. Michigan industries must report annual use and discharge of these toxic substances if they discharge to water of the State or to municipal wastewater treatment plants. Information from the CMR, integrated with existing pollution control programs, is used to better control toxic substances use and discharge.

MINNESOTA PROGRAMS

The Minnesota Pollution Control Agency is responsible for determining the best current uses for the State's waters and the quality of the waters necessary for these uses. In 1976 a toxic substance and biological monitoring program was initiated at 25 locations throughout the State. Locations are selected to enable comparison between samples from polluted areas and those representing natural background levels. The kinds of samples taken depend on the types of analyses required. The four basic sample types are water, sediment, fish, and benthic invertebrates.

The Western Lake Superior Sanitary District was established to provide a comprehensive and coordinated solution to an existing pollution problem created by three pulp and paper mills as well as by other industrial and municipal sources on the St. Louis River and St. Louis Bay of Lake Superior. The new facility is located in Duluth and discharges into St. Louis Bay. The three mills that were previously discharging directly into the Basin have now diverted all their process wastewaters for treatment by this facility.

OHIO PROGRAMS

The Ohio Environmental Protection Agency has the authority within Ohio to deal with pollution problems. This authority is explicit in terms of program development, establishment and enforcement of regulations, and supervision of abatement activities. The Office of Wastewater Pollution Control is responsible for the control and prevention of point source water pollution in the State. Ohio has only four small mills discharging into the Great Lakes Basin. They are in compliance with NPDES permit requirements.

NEW YORK PROGRAMS

In anticipation of administering the federal Clean Water Act, New York State modified its Environmental Conservation Law to conform to the federal law. In 1975 the State was granted authority to administer the federal permit program. Paper mills with direct surface water discharges into the Great Lakes Basin have been issued NPDES permits. The remaining mills discharge into POTW's and are regulated indirectly by the permit of the municipality.

The Clean Water Act required, through the permit program, the implementation of BPT technology limits and the attainment of local receiving water standards by July 1, 1977. Permits for the New York mills currently contain limitations for BPT, water quality limits for conventional pollutants, and water quality limits for certain toxic pollutants (e.g. zinc, phenol).

The next phase of The Clean Water Act is the implementation by 1984 of BCT limits for conventional pollutants and BAT limits for toxics. New York State is waiting for the promulgation of BCT/BAT technology guidelines for the paper industry and intends to incorporate them into permits for achievement by the 1984 compliance date.

Under federal and state laws, dischargers are required to be in compliance with all water quality standards, including those for toxic pollutants. While New York State addressed certain toxics in its initial NPDES permits, it did not comprehensively evaluate the wide range of potentially toxic organic substances. In order to address this area of concern, the State initiated an Industrial Chemical Survey (ICS) program in 1975. The survey required paper mills and other companies to report their annual usage of a broad range of organics referred to as substances of concern. The ICS data are reviewed for potential discharge of these substances. Monitoring programs and/or water quality limits are then established in the NPDES permit.

The ICS review has been completed for some paper mills and at least partially completed for all paper mills directly discharging into the Great Lakes Basin.

The ICS has been incorporated into New York State's NPDES application process, thereby providing periodic updates for the usage of substances of concern and focusing attention on the need to regulate their discharge. Among these substances are PCBs. A recent survey indicated that the median concentration of PCBs in effluents from wastepaper recycling operations is less than 1 ppb (µg/kg). A complete description of the Survey can be found in the proceedings of the North East Regional Meeting of The National Council of the Paper Industry for Air and Stream Improvement, November 1978.

Because of federal and state programs, the pulp and paper industry in New York has substantially reduced pollutant loads to the Great Lakes Basin. The reductions reflect inplant wasteload reductions, construction of external treatment facilities, connections to POTW's, and closure of some mills.

Effluent Limitations in the United States

The 1972 and 1977 amendments to the FWPCA require all industrial dischargers to achieve specified levels of pollutants control in a two-step process: 1) by July 1, 1977, achieve BPT for all pollutants; 2) by July 1, 1984, provide BCT for conventional pollutants such as BOD and TSS, and BAT for all toxic pollutants referred to in Appendix III of this report and also for nonconventional pollutants.

The U.S. EPA promulgated effluent limitation guidelines in two phases, reflecting BPT for subcategories of the pulp and paper industry. The first phase guideline was issued May 29, 1974 and covered unbleached kraft, semichemical, and paperboard from waste paper. The second phase, issued January 6, 1977, established effluent limitations for most of the remaining subcategories. These limitations are shown in Appendix II under the heading BPT and were incorporated in the individual mill discharge permits to be achieved no later than July 1, 1977. The BPT requirements were met in most cases as shown in the 1977 IJC Remedial Programs Subcommittee Report, and additional reductions have been achieved over the past three and one-half years.

Pursuant to the FWPCA amendments (Clean Water Act) of December 1977, the U.S. EPA has studied the industry with the goals of developing BCT effluent limitations for conventional pollutants and BAT effluent limitations for toxic and nonconventional pollutants. Increased emphasis was placed on the control of toxics. Because information on the discharge levels of many of the toxic and nonconventional pollutants shown in Appendix III was limited or unknown, sampling and verification studies were conducted on many of the representative facilities.

Based on the study of the pulp and paper industry, effluent limitation guidelines and standards were proposed in January 1981 for BCT on three conventional pollutants (BOD_5, TSS and pH), and BAT on four toxic pollutants (pentachlorophenol, trichlorophenol, chloroform and zinc) as shown in Appendix II. These proposed limitations, if promulgated, would further reduce conventional pollutant discharges by approximately 45-50% and would limit four toxic pollutants for certain sub-categories.

It must be noted, however, that the U.S. EPA has agreed to a request from the American Paper Institute to delay final action on these proposed regulations until after the publication of EPA's views on the "Council on Wage and Price Stability" study of its BCT cost comparison methodology. In May, 1981 the U.S. EPA also requested that its regional offices and authorized states not issue any permits with BCT or BAT limitations to facilities in the pulp and paper industry until a new directive is issued.

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Discharge Trends in the United States

Appendix IV lists pulp and paper mills discharging directly into the Great Lakes; Appendix V, those discharging indirectly. Tables 2 and 3 show discharge trends of TSS and BOD_5 for Michigan, New York, Wisconsin, Minnesota, and Ohio, the states which have mills discharging into the Great Lakes. Table 4 includes a comparison between the number of mills and production figures of saleable products in the mid-1970's and 1980.

TABLE 2.
TSS DISCHARGE TRENDS OF MILLS DISCHARGING DIRECTLY INTO THE GREAT LAKES
(Megagrams Per Day)

Jurisdiction	1967	1973	1977	1980
Michigan	100.2	45.2	34.9	21.4
New York	265.4	38.6	13.6	6.8
Wisconsin	154.6	79.4	30.8	20.6
Minnesota	44.6	20.7	23.3	0*
Ohio	-	-	.3	.2
Total	564.8	183.9	102.9	49.0

*In 1980 all mills in Minnesota were discharging into municipal systems.
-No data available.

TABLE 3.
BOD_5 DISCHARGE TRENDS OF MILLS DISCHARGING DIRECTLY INTO THE GREAT LAKES
(Megagrams Per Day)

Jurisdiction	1967	1973	1977	1980
Michigan	131.6	51.7	22.8	13.7
New York	106.6	38.4	17.5	4.4
Wisconsin	198.9	147.6	27.5	19.1
Minnesota	144.8	54.9	26.1	0*
Ohio	-	-	.3	.3
Total	581.9	292.6	94.2	37.5

*In 1980 all mills in Minnesota were discharging into municipal systems.
-No data available.

TABLE 4
MID-1970'S AND 1980 PRODUCTION FIGURES OF MILLS DISCHARGING DIRECTLY INTO THE GREAT LAKES

Jurisdiction	Number of Mills Mid-1970's	1980	Saleable Products (Megagrams Per Day) Mid-1970's*	1980
Michigan	21	20	4,269	5,014
New York	18	17	1,840	1,900
Wisconsin	21	22	5,316	6,315
Minnesota	2	0**	740	0**
Ohio	4	4	257	302
Total	66	63	12,422	13,531

* The mid-1970's production figures were adjusted to represent the annual daily average. In the 1977 report, the mid-1970's figures represented the 7-day maximum daily average.

**In 1980 all mills in Minnesota were discharging into municipal systems. Their saleable products in 1980 amounted to 352 megagrams per day.

These tables show only general trends occurring in the various jurisdictions. Comparisons must consider the following:

1. The 1967 discharge data are incomplete and suspect because mills, in many cases, were not required to analyze and report their loadings, and standardized analytical and monitoring procedures were not in use. Some of the discharging mills were not included in the data because monitoring results were not available.

2. The 1973 data are biased because of the shut down of mills for discrete periods during 1967-1977 and the addition of mills that opted out of municipal systems, later becoming direct dischargers with their own treatment systems. Loadings may not be included for these mills in the 1973 data but are included in the 1977 data.

3. Conversely, since 1973 a number of mills have connected to POTWs and send all or part of their raw wastewaters to these treatment systems. Additionally, some mills have closed down completely, discontinued their pulping operations, or changed them.

4. Production variations within each mill between reporting periods are not precisely known. Also, the procedure for reporting production is not standardized among the jurisdictions. For example, some of the mid-1970's United States production figures were reported in 1977 as 7-day maximum daily discharges, while the 1980 figures were reported as annual daily averages. The former method of reporting produces figures which are approximately 15 percent higher than the latter. Since permitted pollutant loadings are based on production, the mills report the highest allowable production to obtain maximum loadings. This production figure need not represent actual production at the time of reporting.

Between 1967 and 1980, TSS discharges into the Great Lakes from the U.S. mills have decreased by approximately 91%; BOD_5 by 94% (Tables 2 and 3). Meanwhile, the number of directly discharging mills has slightly decreased from 66 in the mid-1970's to 63 in 1980 and the production of saleable products has increased by approximately 9% (Table 4).

NOTE: When comparing loadings of suspended solids and BOD_5 between the United States and Canada (Ontario), it should be noted that most Canadian mills are integrated operations, producing most of the pulp used in the manufactured paper products. On the United States side, many of the mills are specialty operations making only paper. Twenty-seven of the 63 direct discharging United States mills manufacture pulp. In Canada, however, 18 of the 22 produce pulp. The amount of conventional pollutants associated with pulp production is usually higher than that associated with paper and other finished products. The United States mills also use a greater amount of recycled fiber than Canadian mills.

Monitoring Protocols

The U.S. EPA promulgated a regulation establishing "Test Procedures for the Analysis of Pollutants" on October 16, 1973, that was amended in December 1976. This regulation provides test procedures for 115 pollutants and includes recommendations for sample preservation techniques and holding times. If preservation techniques and holding times are stipulated in the analytical method, they are regarded as mandatory. Any discharger wishing to use an alternate method of analysis must submit the procedure with supporting documentation to the U.S. EPA and obtain its approval before it can be used for reporting purposes. On December 3, 1979 the U.S. EPA proposed amendments to this regulation to provide analytical methods for 113 organic toxic pollutants.

For the traditional pollutants, BOD and TSS, the Canadian and United States monitoring protocols can be considered equivalent. The problem which some of the analysts encounter is more one of accuracy of results than of specified methods. Because toxicity is specified as a parameter under the Canadian Fisheries Act, Canada has studied the toxicity from pulp and paper mills in greater detail than has the United States. The United States is now developing national procedures for setting effluent limitations based on toxicity.

Pulp and paper mills in the United States which are applying for renewal of their NPDES permits are required to monitor their wastewaters prior to discharge for 13 metals, total cyanide and total phenols. They are also required to determine by the use of gas chromotography/mass spectrometry the quantities of any of the 113 organic toxic compounds which may be present.

Self-Monitoring ~ Quality Assurance Programs

ONTARIO SELF-MONITORING PROGRAMS

In 1968 self-monitoring began modestly with the pulp and paper industry voluntarily submitting quarterly reports on effluent quality. The weekly grab sample was analyzed for four parameters: TSS, BOD_5, pH, and Total Dissolved Solids.

As flow measurement was improved and TSS were reduced, mills installed automatic continuous instruments. A composite sample was automatically made for each day. The pH and temperature were continually measured. By 1977 effluent reports were submitted monthly and reporting requirements became part of new Control Orders for some mills. Reporting requirements will become uniform throughout the province on an industrial sector basis.

In the fall of 1980 the Ministry of the Environment began to develop an automatic recording system called Industrial Monitoring Information System. The data bank will include information on effluents, air emissions, and solid wastes. Excursions above limits set in the Control Orders are reported within 24 hours. Measurements above the limits shown in the monthly reports are investigated to verify that due diligence was used to correct the situation; where due diligence has not been demonstrated, a charge is laid. All regional offices have 24 hour telephone answering services with a duty person on call for any major upsets or emergencies.

ONTARIO QUALITY ASSURANCE PROGRAMS

In Ontario, all the analytical needs for the Ministry of the Environment programs are met by the Central and three Regional laboratories. A common standard of service is maintained, and sampling and analytical procedures are continually evaluated by the Ministry staff.

The Ministry offers annual courses designed to train operators of municipal and industrial waste treatment systems. Treatment principles, concepts, typical calculations, and representative effluent loadings from different industries are taught in these courses.

Regional staff carry out random audits of industrial effluent treatment systems. Previous effluent inspections are reviewed and operating records evaluated. Equipment previously identified as prone to malfunction is inspected. The mill's immediate past operation is discussed with the mill manager. If any changes are considered desirable, either in equipment or its maintenance and operation, the manager is advised accordingly. A follow-up letter is sent to the mill manager.

UNITED STATES SELF-MONITORING PROGRAMS

Industries which discharge pollutants directly into the "waters of the United States" are required by the conditions of their NPDES permits to self-monitor to assure compliance with permit limitations for designated parameters. The permit holder must monitor at the frequencies shown in the permit, using an indicated sample type. The analyses must be conducted according to U.S. EPA approved test procedures. Records must include: the date, the exact place and time of sampling or measurements, the date analyses were performed, the individual who performed the analyses, and the analytical techniques or methods used. If the permit holder monitors any pollutant more frequently than required by the permit, these results must also be reported.

The monitoring results are reported on special forms and sent to the permit issuing authority at specified intervals. All records and information resulting from the required monitoring activities must be retained by the permit holder for a minimum of 3 years.

If a discharger does not comply with a daily maximum effluent limitation specified in the permit, the permit holder must provide the permit-issuing authority with written notification within 5 days of becoming aware of the noncompliance.

UNITED STATES QUALITY ASSURANCE PROGRAMS

A permit holder's facilities can be inspected by either the U.S. EPA or the state to determine compliance with the required limitations and to assure that the required monitoring protocol is used. A summary of Compliance and Quality Assurance (Q/A) programs implemented by the U.S. EPA follows:

- Compliance Evaluation Inspection (CEI) survey designed to be a plant walk-through. This survey could include a review of any of the following:
  - o progress with the compliance schedule;
  - o laboratory procedures;
  - o plant operating procedures;
  - o sampling procedures;
  - o reporting procedures;
  - o operator certification; and
  - o any other permit-related activity.
- Compliance Sampling Inspection (CSI) survey designed to be a detailed plant inspection, which would include the sampling of the permit holder's discharge and any of the other activities under the CEI class.
- Performance Audit Inspections (PAI) to evaluate the permit holder's sampling techniques, analytical procedures, quality control procedures, Discharge Monitoring Report (DMR) data, and compliance schedules.

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- DMR/QA (quality assurance) Evaluations, which are now being carried out under a new program, implemented by the U.S. EPA and the states. The objective of this program is to improve the quality of DMR data. In addition, it is recognized that performance samples are not a complete test, but only one criterion that can be used to evaluate data quality. With this limitation in mind, follow-up actions review the general quality control (QC) practices to ascertain the cause(s) of the unreliable or unacceptable data. Once QC practices have been evaluated and documented, a second set of samples (or selected samples) may be requested. The quality control samples, provided free of charge by the EPA's Environmental Monitoring and Support Laboratory (EMSL) in Cincinnati, Ohio can be used for this re-evaluation. The enforcement agency responsible decides whether re-evaluation is appropriate and whether to request the required samples from EMSL. The known values are provided along with these samples and are retained by the enforcement agency for comparison with the reported analytical values. Only the samples and instructions are provided for the permit holder.

- Where the values show poor QC practices, follow-up actions can be initiated. These actions depend on the severity of the problem. They can vary from an informal telephone contact to a letter, an administrative order, a field investigation, or referral to the appropriate legal department.

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Toxic and Nonconventional Pollutants

Pulp and paper mill effluents contain one of the most complex mixtures of organic and inorganic chemical compounds found in any industrial category. While many of these compounds are naturally occurring chemicals, the processes used in changing trees into paper products or in recycling used paper into new products often involve the addition of chemicals and yield substances which do not occur in nature. The bleaching process, for instance, causes some of the naturally occurring resin and fatty acids to be chlorinated and therefore become more resistant to biological treatment.

A report prepared for Environment Canada by Dr. G. H. Tomlinson II, based on studies at the American Can mill in Marathon, Ontario, provides a theme for the toxic substances problem as it relates to the manufacturing of bleached kraft pulp:

> "In the effluent from a bleached kraft pulp mill, the principal substances responsible for the toxicity to fish can originate from: materials present in the original wood, such as resin and fatty acids; an excess of the reagents used, such as sodium sulfide and chlorine; lignin degradation products, such as methyl mercaptan which is formed during digestion of the wood, and dichlorostearic acid which is formed during bleaching of the pulp.
>
> From both the toxic and quantitative standpoints, the resins form the most serious problem. They originate in the resin ducts of conifers, and in the living tree are exuded onto the ends of broken branches to prevent the serious loss to moisture from the tree which could otherwise result. During the wet debarking operation of the logs, the resin is emulsified and can pass into the effluent. During digestion of the chips, it is saponified to form resin acid soaps, while at the same time, volatile terpenes are liberated. The resin soaps are the sodium salts of a number of chemically related acids, namely abietic acid, dehydroabietic acid, pimaric acid, sandarocopimaric acid, laevopimaric acid, and isopimaric acid. Sodium abietate has been used commercially as a heavy-duty laundry soap.
>
> Softwoods, and particularly pine, contain substantial amounts of resin. Some studies have indicated that resin acid soaps are the most likely candidates of known composition to be present in the final effluent in concentrations high enough to affect the LC_{50} values*. Therefore, special attention has been given in the present study to following the fate of resin acid soaps.

*LC_{50} is the concentration that is lethal to 50% of the fish in 96 hours when held under standardized test conditions. Thus a low LC_{50} value indicates high toxicity.

Sulfides and mercaptans oxidize relatively rapidly. They may be oxidized in the mill effluent system, and even after sampling, before or during, the toxicity test.

These soaps act differently from poisons that are ingested and build up in the food chain, and their toxic effect is limited to gilled organisms. In order to obtain oxygen needed for their metabolism, fish must pass large quantities of water through the gills. Resin acid soaps, which are surface active substances, are absorbed on the gills and thus interfere with oxygen transfer. Depending on the specific resin soaps involved, LC_{50} values of 0.7 to 1.6 mg/L are obtained with this class of compounds. The half-life of dehydroabietic acid in the water column is about 6 weeks.

Fats are stored in the ray cells of the wood, and act as food reserves during the winter for forming the buds and needles in the spring. The fats are hydrolyzed during the kraft pulping to form glycerol and fatty acid soaps. These latter are normally associated with the resin acid soaps in the pulp mill liquors and effluents. The LC_{50} concentrations of the unsaturated fatty acids, oleic, linoleic and linolenic acids are approximately an order of magnitude higher than those of the resin acids. However, oleic acid can become chlorinated to form dichlorostearic acid and epoxystearic acid. Both are substantially more toxic than the oleic acid from which they were formed so that it is desirable to efficiently remove oleic acid from the unbleached pulp so that it does not become chlorinated in the bleach plant and enter the effluent. The toxicity of the saturated fatty acids is substantially less than that of the unsaturated fatty acids and the LC_{50} values are well out of the range of their likely concentration in pulp mill effluents."

Dr. Tomlinson distinguished the toxic components in pulp and paper mill effluents into two categories, "fugitive" and "non-fugitive". The fugitive components of pulp and paper effluent probably constitute the major portion of the toxicants. Effluents stored for a period of time or agitated using nitrogen or some other inert gas will lose their toxicity fairly rapidly. This phenomenon is attributed to the loss of "fugitive" components such as chlorine, sulphide, (obviously in different process streams), chlorinated volatile organics such as chloroform and chloroacetones, mercaptans and other volatile sulphides, terpenes, and numerous other components only some of which have been identified. Fugitive toxicants could also include those components which are easily biodegradable or oxydizable. Hence, the majority of the toxic or potentially toxic components of pulp mill effluents are considered to be in the category of fugitive. Persistent toxicants such as phenolics, resin and fatty acids, and lignin fragments (either free or chlorinated) represent small quantities in the effluent but in some cases are highly toxic.

Several recent surveys of pulp and paper mill effluents have been performed, yielding long lists of organic and inorganic constituents. Those constituents which appear in Appendices 1 and 2 of the Agreement are included in Table 5. In addition, the State of Wisconsin surveyed several pulp and paper mills on the Fox River and identified 105 compounds. Subsequent to that effort, all major mills in the State were required to sample for toxic constituents in their discharge.

TABLE 5.
COMPOUNDS FOUND IN PULP AND PAPER MILL EFFLUENTS WHICH APPEAR IN APPENDIX 1 OR APPENDIX 2 OF THE GREAT LAKES WATER QUALITY AGREEMENT

Appendix 1	Appendix 2
Ammonia	Cadmium
Benzene	Chromium
Mercury	Copper
Chlordane	Dibutyl phthalate
Chlorobenzene	
Chloroform	
Cresol	
DDT	
Lead	
Napthalene	
Nickel	
Pentachlorophenol	
Phenolics	
Phosphorus	
PCBs	
Selenium	
Toluene	
Trichlorophenol	
Xylene	
Zinc	

A few of the constituents of pulp and paper mill effluents (e.g. chlordane and DDT) have been identified as contaminants from their past usage in agriculture and forestry. Two others, ammonia and phosphorus, are commonly-added nutrients to assist in the biological treatment of pulp and paper mill wastes. Treated effluents are usually low in ammonia and phosphorus; however, overdosing sometimes occurs.

Three phenolic compounds: phenol, pentachlorophenol, trichlorophenol which appear in Appendix 1 of the Agreement are found in the pulp and paper effluents. Phenolics are found in the effluents as a result of the partial or complete breakdown of the larger lignin phenolic polymer during the cooking or bleaching process. Chlorinated phenols are noted for causing tainting problems in fish, and taste and odor problems in public water supplies. In addition, both pentachlorophenol and trichlorophenol are known to be contaminated with certain dioxins. Due to their persistence, toxicity, and bioaccumulation potential, these dioxins may pose an environmental threat even at low levels. Both United States and Canadian agencies are aware of these problems and are planning to regulate the discharge of chlorinated phenolic compounds more closely in the future. The sodium salts of these compounts have not been registered in Canada as a fungicide or slimicide in the pulp and paper industry since January, 1981. However, the sodium pentachlorophenate may still be found in coating clays, for instance, and are unlikely to be found in the effluent. The U.S. EPA has proposed that the use of trichlorophenol and pentachlorophenol salts be prohibited and other compounds be used in their place. While it has been suggested that these compounds are also formed during the bleaching process, both Canadian and United States officials agree that they are not. Thus, if either trichlorophenol or pentachlorophenol are found in the discharges, they have either been added or are contaminants in materials entering the mill.

Other compounds found in pulp and paper mill effluents include chloroform and dibutyl phthalate. Chloroform is formed where chlorine or chlorine - containing compounds are used to bleach pulp. It appears to be readily removed during biological treatment either through volatization or breakdown. Low concentrations can be found in some effluents. Enhanced treatment would probably reduce chloroform to below detectable limits.

Dibutyl phthalate is used as a defoaming agent in the paper production process. Its presence may also result from contamination of packaging materials used in the production of foods and beverages or contamination of tubing used to collect samples. Annex 1 of the Agreement has a specific objective for dibutyl phthalate of 4.0 μg/L for the protection of aquatic life. In view of the possible use and occurrence of dibutyl phthalate in the industry, this compound should be monitored and, where necessary, appropriate limitations developed.

Benzene proper as well as several benzene compounds including chlorobenzene, methylbenzene (toluene), ethylbenzene, and nitrobenzene have also been found in pulp and paper mill effluents. Benzene and its associated compounds are widely used in industry as chemical intermediates, thinners, cleaners, and general solvents. They are also used in the preparation and use of inks. Thus, their appearance in mill effluents is not at all surprising.

Based upon octanol/water partition coefficients, benzene, ethylbenzene, methylbenzene, and nitrobenzene should bioaccumulate only slightly. Because these compounds are volatile, levels should be kept below concentrations which may cause acute or chronic toxicity to aquatic life. The chlorinated benzenes may present a different problem since they have a high lipid solubility and are expected to accumulate in ecosystems.

Naphthalene, also widely used by industry in formulating solvent lubricants and in producing dye compounds, occurs in pulp and paper mill effluents. Napthalene can oxidize in light and air, and some microorganisms can degrade naphthalene ultimately to carbon dioxide and water. Thus, good biological treatment may be effective in removing naphthalene. Where it is found in mill effluent at levels of concern, appropriate limitations should be developed to protect aquatic life.

PCBs are another class of chlorinated organics which are found in some mill discharges, particularly those using recycled paper (deinking mills). PCBs were used in "no-carbon-required" paper in the late 1960's and early 1970's. When such paper was recycled the PCBs contaminated other papers. The use of PCBs in this paper was discontinued in the early 1970's. However, PCBs continue to be found in discharges from mills using recycled paper due to residual contamination. Because PCBs are adsorbed onto suspended solids, it seems prudent to place tight limitations on suspended solids where PCBs are known to occur.

Recent measurements of PCB concentrations at Wisconsin mills which recycle paper indicate that one large mill with only 1-3 µg/L of PCB in the effluent will discharge approximately 23 - 45 kg/year of PCBs into Lake Michigan. The U.S. EPA and the State are working with the dischargers to significantly reduce these levels.

The presence of sodium in mill effluents would normally be of no concern. This element is used in some chemical processes and sodium hydrosulfite is now being substituted for zinc hydrosulfite as a bleaching chemical. Recently, however, it has been suggested that increased sodium levels may be responsible in part for changes in algal assemblages in Lake Michigan. Algal shifts to blue-greens are thought to occur at sodium levels of 5-6 mg/L. Thus, in Lake Michigan where sodium levels are approaching this threshold, sources of sodium, such as pulp and paper mills are of some concern.

Two remaining compounds, cresol and xylene have been found in pulp and paper effluents. Cresols (methyl phenols) are widely used in industry as disinfectants, fungicides, solvents, intermediates, and as additives to metal cleaners and motor oil. Technical grade cresols commonly contain xylenols and phenols. Cresols are relatively easily metabolized by microorganisms and are unlikely to undergo significant bioaccumulation. Thus, biological treatment may effectively remove most cresol. It may be necessary to develop limitations to protect aquatic life if significant levels of cresol are found in a discharge.

Xylene (dimethylbenzene) is also a common industrial chemical used in solvents (to replace benzene), lacquers, enamels, protective coatings, and in a wide variety of consumer goods such as caustics and household aerosols. Xylenes are expected to bioaccumulate in fish and shellfish and cause tainting. Bacteria oxidize xylenes and, therefore, adequate biological treatment may reduce them to acceptable levels. However, if present in an effluent, their levels should be monitored and limited to protect fish and shellfish from tainting.

As noted previously, pulp and paper mill effluents are chemically extremely complex. Those compounds discussed above are only a few of hundreds which are used or formed in the processes and subsequently found in the effluent.

Of those substances discussed above, all but five - ammonia, cresol, phosphorus, sodium, and xylene - are found on the U.S. EPA list of 129 chemicals for which criteria documents have been developed. Much more information concerning these substances can be found in those documents.

In addition, many substances not listed in Annex 1 or Appendices I and II of the Agreement have been reported in pulp and paper mill effluents and are listed on the EPA list of 129 chemicals for which criteria have been developed (Appendix III of this report). Appendix III also lists the 14 major toxicants found in pulp and paper mill effluents, including seven resin and fatty acids, four chlorinated fatty and resin acids, two phenols, and xylenes.

Recent measurements of PCB concentrations at Wisconsin mills which recycle paper indicate that one large mill with only 1-5 ug/L of PCB in the effluent will discharge approximately 25 - 45 kg/year of PCBs into Lake Michigan. The U.S. EPA and the State are working with the dischargers to significantly reduce these levels.

The presence of sodium in mill effluents would normally be of no concern. This element is used in some chemical processes and sodium hydrosulfite is now being substituted for zinc hydrosulfite as a bleaching chemical. Recently, however, it has been suggested that increased sodium levels may be responsible in part for changes in algal assemblages in Lake Michigan. Algal shifts to blue-greens are thought to occur at sodium levels of 5-8 mg/L. Thus, in Lake Michigan where sodium levels are approaching this threshold, sources of sodium, such as pulp and paper mills are of some concern.

Two remaining compounds, cresol and xylene have been found in pulp and paper effluents. Cresols (methyl phenols) are widely used in industry as disinfectants, fungicides, solvents, intermediates, and as additives to metal cleaners and motor oil. Technical grade cresols commonly contain xylenols and phenols. Cresols are relatively easily metabolized by microorganisms and are unlikely to undergo significant bioaccumulation. Thus, biological treatment may effectively remove most cresol. It may be necessary to develop limitations to protect aquatic life if significant levels of cresol are found in a discharge.

Xylene (dimethylbenzene) is also a common industrial chemical used in solvents (to replace benzene), lacquers, enamels, protective coatings, and in a wide variety of consumer goods such as caustics and household aerosols. Xylenes are expected to bioaccumulate in fish and shellfish and cause tainting. Bacteria oxidize xylenes and, therefore, adequate biological treatment may reduce them to acceptable levels. However, if present in the effluent, their levels should be monitored and limited to protect fish and shellfish from tainting.

As noted previously, pulp and paper mill effluents are chemically extremely complex. Those compounds discussed above are only a few of hundreds which are used or formed in the processes and subsequently found in the effluent.

Of those substances discussed above, all but five - ammonia, cresol, phosphorus, sodium, and xylene - are found on the U.S. EPA list of 129 chemicals for which criteria documents have been developed. Much more information concerning these substances can be found in those documents.

In addition, many substances not listed in Annex 1 or Appendices I and II of the Agreement have been reported in pulp and paper mill effluents and are listed on the EPA list of 129 chemicals for which criteria have been developed (Appendix III of this report). Appendix III also lists all parameters found in pulp and paper mill effluents, including seven resin and fatty acids, four chlorinated fatty and resin acids, two phenols, and xylenes.

Mill Improvement and New Technology

The problem of high BOD and suspended solids discharges from the pulp and paper industry in former years was attributed to: the availability of cheap raw materials, both wood and chemicals; high capital cost of equipment; and the lack of low-polluting modern processes. In recent years, however, intense environmental concern, escalating wood and labour costs, and high energy costs have forced the industry to modernize older mills and to develop highly efficient, low-polluting processes in order to offset these factors. The main objective was to maximize the use of raw materials, and at the same time, produce a product which could meet the ever-increasing demands of high speed paper machine and printing presses.

When a mill is modernized, economic considerations usually limit the changes to readily-achievable rather than the best available improvements. For instance, if the batch digestors in a 25 year old bleached kraft pulping mill are in good condition, this process will be enhanced by adding vacuum pack equipment, automatic capping, better indirect heating and computer control of the operating variables. With these modifications, the process will operate more uniformly and consistently. Meanwhile, the operation of the downstream processes will improve; the brown pulp washers performance will be better; and there will be fewer spills to sewers. Generally, there will be fewer organic compounds in the pulp to be processed in the bleachery plant. Thus, the organic load in the bleachery wastewater will be reduced.

A more fundamental change may require the replacement of the existing small batch digestors with a few larger ones or the installation of one continuous digestor. This latter change results in further marginal reduction in the discharge of raw wastes.

Typical changes in an existing bleached kraft mill may include some or all of the following:

- The digestor may be changed as outlined above.
- The blowheat accumulator capacity may be expanded to recover more of the hot water and the associated organic compounds such as soaps, tall oil, and turpentine.
- New or additional brown pulp washers may be installed to decrease the amount of weak black liquor sewered.
- Pressurized pulp cleaners may be installed to prevent rejects from entering the sewers.
- The bleachery plant may be modernized by using chlorine dioxide rather than chlorine in the first stage of bleaching and by changing to countercurrent flow and recycling hot water from other mill processes.
- A condensate stripper may be installed and the resulting clean hot water may be used in the mill.

- The multi-effect evaporator capacity may be expanded to increase the solids contents of the black liquor and decrease the carry over of organics and inorganics into the condensates.
- A new lime kiln may be installed to improve fuel utilization
- The causticizer system may be replaced to increase white liquor solids and decrease inorganics discharges.
- The recovery of bark, rejects, etc. from wastewaters may be increased so that more wood refuse may be used as fuel and the amount of solids in the wastewater may be reduced.
- Heat recovery from the pulp dryer may be increased by the installation of a better exchanger.

Not every existing bleached kraft mill would make all these changes. An improved kraft mill, however, may achieve some or all of the objectives outlined in Table 6.

TABLE 6. OBJECTIVES OF MILL IMPROVEMENT PROGRAMS

Parameter	Objective (per megagram of product pulp)	Achievement
Wood usage	1.777 cunits (a volume measure of logs)	Increased fiber production, about 2% less wood is used.
Energy usage	30×10^6 BTU	Less total energy is used, reduction is approximately 18%, combined use of oil, natural gas, wood refuse, electricity is improved, better heat recovery and conservation.
Water usage	45 m^3	Spills are reduced 2/3 in terms of number and quantity.
TSS	5.5 kg	Total suspended solids are reduced when pressurized screens, save-alls and clarifiers are used.
BOD_5	23 kg	Biochemical oxygen demand of the raw discharge is reduced.

Depending upon the product, a paper mill may be able to convert to dry forming on its paper machine. This change will reduce water usage, fiber loss, and energy consumption.

New processes have also been developed which have altered the requirement to treat pulp and paper mill effluents. Concern with energy conservation has intensified the need to recycle process streams, thereby reducing the quantities of effluents which might have to be treated. In many cases, the right combination of new processes and extensive recycling can obviate the necessity to treat effluents externally. Consequently, capital and operating costs are reduced.

In addition to the modernization programs for reducing conventional pollutants, new technologies are being used in Canada and the United States to reduce toxic loads in pulp and paper mill effluents. The objective is to modify the manufacturing processes in order to minimize the production of toxic materials and/or to recycle those that are produced back through the recovery processes so that they do not reach the surface waters. The following is a brief description of some of the technology which is now being used in some of the pulp and paper mills to reduce both conventional and nonconventional pollutants.

THE CLOSED-CYCLE SYSTEM

The main objective of a closed-cycle system is to recycle as much as possible of the internal process streams. The installation of the a closed-cycle system at the Great Lakes Forest Products mill in Thunder Bay, Ontario, has been relatively successful. A number of technological advances have resulted from this installation, even though there are still continuing problems particularly those related to corrosion. It has been clearly demonstrated that the closed-cycle process can accomplish its fundamental objective of recycling bleachery streams, and that the chloride content of the white liquor can be controlled to an acceptable level by the a salt removal process. Fundamental to this recycling issue is the fact that water consumption in the bleached kraft pulp mill can be gradually reduced from its former level of 100 - 150 m^3/tonne to a level of about 14_3- 17 m^3/tonne. Currently, Great Lakes Forest Products is using 22 - 24 m^3/tonne of water. This water reduction results in reduced energy costs. Operating the bleachery stages at more or less constant temperatures avoids the wide temperature swings encountered in the conventional bleachery. Thus, energy used in cooling and heating is saved. The key to the high temperature operation is in the chlorination stage, where the use of a mixture of chlorine and chlorine dioxide can allow much higher temperatures without adversely affecting the pulp quality.

The closed-cycle process has shown that pulp quality is in fact slightly enhanced, and less scaling is encountered in the digesters and evaporators than is found in a conventional mill.

Mills which have closed-up most of their process streams, except the bleachery, have discharges that are equivalent to or slightly less than could be accomplished with a five-day aerated lagoon treatment system. The advantage of this process over treatment is that the materials (effluents) discharged are more biodegradable than in the conventional mill where much of the lignin material which enters the treatment system is not biodegraded and reaches the surface waters essentially unchanged. Another advantage is that the effluent colour is markedly reduced because of the absence of these lignin compounds.

SUBSTITUTION OF CHLORINE DIOXIDE FOR CHLORINE

Until the mid-1960's, conventional kraft bleaching technology had the sequence CEDED (bleaching with chlorine followed by the first stage of extraction with sodium hydroxide, then application of chlorine dioxide followed by the second stage of extraction and finally the second stage of chlorine dioxide). This technique produced an effluent which contained many materials toxic to fish, including chlorinated organics. Recent studies, however, indicate that the substitution of chlorine dioxide for 30% or more of the chlorine in the first stage resulted in an effluent having little or no toxicity to fish. It was also demonstrated that chlorine dioxide substitution reduces or eliminates positive Ames and chromosome aberration effluent test responses. While the BOD_5 content was not significantly reduced, the amount of chlorinated organics was lower.

This finding led to the conclusion that chlorine dioxide alters the bleaching process to an oxidation rather than a substitution reaction. It has become standard practice for a number of mills to use chlorine dioxide as a substitute for chlorine in the first bleaching stage, not only because the environment benefits, but also because pulp qualities and yield are usually enhanced. The inhibiting factor at the moment, however, is that chlorine dioxide is extremely corrosive. Suitable metals must, therefore, be used in the construction of the equipment. It has been concluded that using chlorine dioxide is one way of reducing environmental effects.

MECHANICAL PULPING PROCESSES

In the past 15 years major advances have been made in the production of mechanical pulp. Formerly, groundwood was produced from whole logs (2 to 4 ft. long) using a rotating grindstone. As lumbering operations became more intensified and modernized, more residual wood became available. Some of this wood was low grade and could not be used in some conventional chemical pulping operations. In an effort to utilize this cheap source of raw material and at the same time to maximize the use of the whole log, it was necessary to develop a process for producing mechanical pulp from chips and sawdust. The first refiner pulping process was developed in the United States in the late 1950's. This was followed by the Swedish development of thermomechanical pulping (TMP), a steam-pressurized version of refiner pulping. Recently there have been two major Canadian developments in the area of chemically modified TMP, either before or after the refining operation.

As a result of these developments, sulphite pulping, used in eastern Canadian newsprint, can now be replaced by one or the other of these refiner-type methods of pulping. Consequently BOD_5 is reduced from a range of 75 - 125 kilograms per megagram to a range of 25 - 37.5 kilograms per megagram. Moreover, the effluents from these processes are much easier to deal with because of their nature, and the systems (if necessary) to treat effluents are less expensive to install and operate. Furthermore, with higher oil prices, emphasis is on using Canada's abundant hydro electric power whenever possible as a more reliable energy source. A major side benefit of the mechanical pulping processes is the increased yield. Sulphite pulping has a yield of 50 - 70%, while mechanical pulping processes have yields of 90 - 95%. Research is underway to determine if a TMP newsprint mill can be operated as a closed process mill. In summary, a combination of environmental problems, costs of energy, raw materials, and overall operation have succeeded in forcing the rapid acceptance and advancement of the mechanical pulping technology.

EVAPORATOR CONDENSATES

Kraft mill evaporator and digester condensates are major sources of toxic chemicals. The efficient removal or treatment of these toxic chemicals has become an important area of investigation. A number of attempts have been made to define the amount of stripping that must be done to reduce the toxic components to an acceptable level for discharge. One of the more promising techniques is to use recovery boiler or other flue gases to strip the toxic materials from the condensates. Recovery boiler and lime kiln flue gases have considerable heat content due to their high moisture content. This heat content (enthalpy), rather than the more expensive steam, could be used to strip the volatile material from condensates for disposal by incineration. If this system can be integrated with a heat recovery system, heat can be recovered from the stripped condensates.

REVERSE OSMOSIS

Reverse osmosis is employed by Green Bay Packaging, Inc. of Green Bay, Wisconsin, where 270 megagrams per day of corrugating medium is produced from a combination of neutral sulfite semichemical (NSSC) pulp and recycled waste fiber. The strong NSSC pulping liquors are burned in a Dorr-Oliver fluid bed combustion plant. Clarified excess process water is sent through a heat exhanger to remove excess heat and to preheat boiler makeup water. It then passes through the reverse osmosis system from which the concentrate is directed to a pulp mill wash dilution tank to be used in the countercurrent liquor washing operation. The resulting permeate is discharged into the river. Use of the system has reduced the BOD from 44 megagrams per day in 1971 to less than 2.2 megagrams per day. In addition, the reverse osmosis system removes essentially all resin and fatty acids.

SULFUR-FREE - SEMICHEMICAL PULPING

Many mills producing semichemical corrugating medium by the neutral sulfite semichemical (NSSC) process are converting to sulfur-free processes. The conversion is being made for three reasons: 1) poor markets for the salt cake by-product produced by NSSC pulping; (2) high chemical costs because sodium sulfate and soda ash cannot be recycled; and 3) reduced forms of sulfur emissions lead to odour problems. Effluents from this type of semichemical pulping are reported to be less toxic than kraft mill effluents. Toxic materials such as dimethyl sulfide are not present, but the resin acids are. Raw BOD_5 waste loads are similar to those using sulfur-based processes.

OXYGEN DELIGNIFICATION

Oxygen pulping is being developed as a means of producing a high strength chemical pulp without the odour problems associated with the kraft pulping process. Oxygen alkali pulping is essentially a soda pulping process followed by an oxygen delignification or oxygen bleach stage. The combination of the soda pulping and oxygen delignification yields a pulp suitable for bleaching, using chlorine dioxide. Oxygen pulping itself offers several advantages, primarily that the chlorination and first extraction stages in the bleach plant are no longer required. Nearly 80 percent of the bleach plant BOD is contained in these operations. Total BOD raw waste loadings from an oxygen pulp mill is about 9.5 - 10.6 kilograms per megagram pulp versus 64.6 megagrams for a market bleached kraft pulp mill. Conditions present during oxygen pulping destroy resin and fatty acids that are responsible for toxicity in many pulp mill effluents. Bioassay tests have shown that oxygen pulping liquors are non-toxic.

Glossary of Terms

Ames Test	A test for mutagenicity based on strains of mutant bacteria. By placing the bacteria on the proper medium and observing the development of colonies, it is possible to count the number of mutations produced by a given concentration of a toxic compound.
BAT	Best Available Technology Economically Achievable
BCT	Best Conventional Pollutant Control Technology
Benthic survey	Survey of organisms which live on the bottom of a river, lake, etc.
BOD	Biochemical Oxygen Demand
BPT	Best Practicable Control Technology Currently Available
Conventional pollutants	Refers to total suspended solids and biochemical oxygen demand
FWPCA	Federal Water Pollution Control Act
LC_{50}	Median Lethal Concentration
Megagram	One thousand kilograms, i.e. a tonne
NPDES	National Pollutant Discharge Elimination System
PCB	Polychlorinated Biphenyl
pH	The negative logarithm of the hydrogen ion concentration (activity)
POTW	Publicly-Owned Wastewater Treatment Works
Save-all	Equipment used to recover fibres and filler from water
TSS	Total Suspended Solids
Tall oil	A resinous by-product from the manufacture of chemical wood pulp used in making soaps, coatings, and oils

Terms of Reference

PULP AND PAPER POINT SOURCES TASK FORCE

The Task Force will:

1. Identify all mills discharging to the basin, direct, indirect and through municipal systems.
2. Identify all VI 1(b) requirements currently imposed by jurisdictions.
3. Discuss variability and comparability between jurisdictional requirements identifying the basis of comparison as appropriate.
4. Provide historical and current loadings for regulated parameters and where possible identify projected loading changes due to new requirements and/or new or emerging technologies.
5. Review the adequacy of self monitoring programs to meet the above requirements.
6. Review and identify, where possible, similarities and/or differences in monitoring protocols.
7. Recommend changes in jurisdictional requirements that may be required to meet the requirements of Article VI 1(b).
8. Prepare a draft report on the above for the WQB report by May 31, 1981 and a final report by June 30, 1981.

Membership List

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Report to the

Great Lakes Water Quality Board

The Response of the Pulp and Paper Industry in the Great Lakes Basin to Pollution Abatement Programs

Appendix

APPENDIX I. CANADIAN EFFLUENT LIMITATIONS

Permitted Deposits of Total Suspended Solids in the Effluent of Mills in Kilograms per Tonne* (Megagram)

COLUMN I	COLUMN II	COLUMN III	COLUMN IV	COLUMN V
Component Category	Existing kraft, sulphite or semi-chemical mill	New expanded or altered kraft, sulphite or semi-chemical mill	Existing mechanical mill	New expanded or altered mechanical mill
1. Wood rewashing	2.5	2.5	2.5	2.5
2. Debarking Hydraulic Process	2.5	2.5	2.5	2.5
3. Debarking - Wet Drum Process	5	4	5	4
4. Pulping	3.5	2.5	6.5	5
5. Bleaching	3	2	1	1
6. Pulp Sheet Formation	1	0.5	2.5	2
7. Integrated, Single Product Paper Making	1.5	1	2.5	2
8. Integrated, Specialty Product Paper Making	3	2	5	4
9. Tissue Paper Making	7.5	5	10	7.5
10. Fine and Specialty Multi-product Paper Making	12.5	10	12.5	10
11. Cylinder Paper of Paper Board Manufacture	7.5	6	7.5	6
12. Neutral Sulphite Semi-chemical Corrugating Medium	3.5	3.5		

* - "Tonne" means in respect of a component process category in:
  a. items 1 to 3, an oven-dry tonne of wood processed without the bark;
  b. items 4 to 6, an air-dry tonne of product; and
  c. items 7 to 12, a tonne of product as produced.

APPENDIX I. CONT'D.

Permitted Deposits of Oxygen-Demanding Decomposable Organic Matter in Kilograms of BOD per Air-Dry Tonne (Megagram)

COLUMN I Type of Process	COLUMN II Existing Mill	COLUMN III New, Altered and Expanded Mill
Sulphite pulping yield of 55% or less	127.5	85
Sulphite pulping yield of more than 55% and less than 65%	85	57.5
Sulphite pulping yield of 65% or more	75	37.5
Sulphite bleaching (market pulp)	17.5	17.5
Kraft pulping	32	16.5
Kraft bleaching	13.5	13.5
Neutral sulphite semi-chemical pulping	40	30

Examples

The quantities of BOD_5 and suspended solids are determined by adding the appropriate allowances for each process component category that the mill uses, and multiplying by the daily production rate. Three examples are outlined below:

Abitibi-Price, using the sulphite and groundwood pulping processes, produces newsprint at the Fort William/Thunder Bay mill at 317 megagrams per day. This mill was initially constructed in 1921 as a groundwood mill.

American Can, a kraft mill at Marathon, Ontario produces a bleached pulp sheet at the rate of 417 megagrams per day. This mill is now undergoing the first phase of modernization since its construction in 1945.

Kimberly-Clark of Canada, St. Catharines, Ontario produces 76 megagrams per day of tissue from pulp. This mill originally established in 1912.

APPENDIX I. CONT'D.

Mill	Production (Megagrams)	FEDERAL ALLOWABLE TOTAL SUSPENDED SOLIDS Debarking (Kilograms)	Pulping (Kilograms)	Bleaching (Kilograms)	Sheet (Kilograms)	Total (Kilograms)
Abitibi Price	317	1,632*	1,992.5*	0	706	4,330.5
American Can	417	0	1,459.5	1,251	417	3,127.5
Kimberly Clark	76	0	0	0	674.6**	674.6

*Based on 25% sulphite pulp with a 55% yield and 75% groundwood with a 90% yield.
**Uses a mixture of 20% chemical and 80% mechanical pulp.

Mill	Production (Megagrams)	FEDERAL ALLOWABLE BOD_5 Pulping (Kilograms)	Bleaching (Kilograms)	Total (Kilograms)
Abitibi Price	317	26,945	0	26,945
American Can	417	13,344	5,629.5	18,973.5
Kimberly Clark	76	0	0	0

APPENDIX II. BAT-BCT-BPT EFFLUENT LIMITATIONS IN KG/MEGAGRAM OR LBS/1000 LBS.

Subcategory	Maximum 30 Day Average BOD₅ BCT[1]	BOD₅ BPT[2]	TSS BCT	TSS BPT	Maximum Day BOD₅ BCT	BOD₅ BPT	TSS BCT	TSS BPT	Maximum Day PCP BAT[1]	TCP BAT[1]	Zinc	Chloroform
Dissolving Kraft	7.2	12.25	11.3	20.05	12.2	23.6	18.6	37.3	0.0057	0.0069		0.055
Market Bleached Kraft	6.2	8.05	8.0	16.4	10.5	15.45	13.2	30.4	0.0043	0.0052		0.042
BCT Bleached Kraft	4.5	7.1	6.6	12.9	7.5	13.65	10.8	24.0	0.0037	0.0044		0.035
Fine Bleached Kraft	3.5	5.5	5.6	11.9	5.9	10.6	9.2	22.15	0.0032	0.0039		0.031
Soda	3.5	7.1	5.6	13.2	5.9	13.7	9.2	24.5	0.0032	0.0039		0.031
Unbleached Kraft	-	2.8	-	6.0	-	5.6	-	12.0				
Linerboard	2.0	2.8	3.7	6.0	3.5	5.6	6.2	12.0	0.0013	0.0016		
Bag	2.7	2.8	4.4	6.0	4.5	5.6	7.2	12.0	0.0013	0.0016		
Semi-Chemical	3.1		4.4		5.3		7.2		0.0011	0.0013		
Sodium base	-	4.35	-	5.5	-	8.7	-	11.0				
Ammonia base	-	4.0	-	5.0	-	8.0	-	10.0				
Unbleached Kraft & Semi-Chemical	3.1	4.0	5.3	6.25	5.3	8.0	8.7	12.5	0.0015	0.0018		
Dissolving Sulfite Pulp												
Nitration	21.5	21.55	38.0	38.05	41.4	41.4	70.6	70.65				
Viscose	23.1	22.05	38.0	38.05	44.3	44.3	70.6	70.65				
Cellophane	25.0	25.0	38.0	38.05	48.1	48.05	70.6	70.65				
Acetate	27.1	26.45	38.0	38.05	52.0	50.4	70.6	70.65				
Papergrade Sulfite	(3)		(3)		(3)		(3)		(4)	(4)	(4)	(4)
Drum Wash		13.9		23.65		26.7		43.95				
Blow Pit Wash		16.55		23.35		31.8		43.95				
Groundwood-Thermo-Mechanical	2.3	5.55	3.7	8.35	3.9	10.6	6.2	15.55	0.0022	0.0026	0.26	
Groundwood-CMN Papers	2.7	3.9	3.8	6.85	4.5	7.45	6.3	12.75	0.0025	0.0030	0.30	
Groundwood-Fine Papers	2.4	3.6	3.5	6.2	4.1	6.85	5.9	11.75	0.0023	0.0027	0.27	
Groundwood-Chemi-Mechanical	(5)	7.05		10.65		13.5		19.75				
Deink												
Fine Papers	5.3	9.4	7.6	12.95	8.9	18.1	12.5	24.05	0.0025	0.0031		0.024
Tissue Papers	5.8	9.4	9.1	12.95	9.8	18.1	15.0	24.05	0.0025	0.0031		0.024
Tissue Papers (FWP)	3.9	7.1	4.7	9.2	6.6	13.7	7.8	17.05	0.0017	0.0020		
Paperboard from Waste Paper	0.74	1.5	0.89	2.5	1.2	3.0	1.5	5.0	0.00032	0.00039		
Wastepaper Molded Products	1.1	(6)	2.1	(6)	1.8	(6)	3.5	(6)	0.00059	0.00071		
Builders' Paper and Roofing Felt	3.0	3.0	3.0	3.0	6.0	6.0	6.0	6.0	0.0015	0.0018		

APPENDIX II. CONT'D.

Subcategory	Maximum 30 Day Average BOD_5 BCT	BOD_5 BPT	TSS BCT	TSS BPT	Maximum Day BOD_5 BCT	BOD_5 BPT	TSS BCT	TSS BPT	Maximum Day PCP (BAT)	TCP (BAT)	Zinc (BAT)	Chloroform (BAT)
Nonintegrated Fine Papers	2.3	4.25	2.5	5.9	3.9	8.2	4.1	11.0	0.0016	0.0019		
Nonintegrated Tissue Papers	5.2	6.25	4.1	5.0	9.4	11.4	8.5	10.25	0.0020	0.0024		
Nonintegrated Lightweight Papers												
Lightweight	10.4	(6)	8.3	(6)	18.9	(6)	16.9	(6)	0.0040	0.0048		
Electrical	18.1	(6)	14.4	(6)	32.8	(6)	29.5	(6)	0.0070	0.0084		
Nonintegrated Filter Nonwoven Papers	12.9	(6)	10.3	(6)	23.4	(6)	21.1	(6)	0.0050	0.0059		
Nonintegrated Paperboard	3.5	(6)	2.8	(6)	6.3	(6)	5.8	(6)	0.0014	0.0016		

(1) Best Conventional Pollutant Control Technology (BCT) and Best Available Technology Economically Achievable (BAT) were proposed on January 6, 1981.

(2) Best Practicable Control Technology Currently Available (BPT) was promulgated on May 29, 1974 and January 6, 1977.

(3) Papergrade sulfite equations for BOD and TSS

Maximum 30 Day Average:

$BOD_5 = 0.002x^2 - 0.104x + 6.61$

$TSS = 0.033x^2 - 0.177x + 11.20$

Maximum Day:

$BOD_5 = 0.0033x^2 - 0.176 + 11.1$

$TSS = 0.0055x^2 - 0.291 + 18.4$

where x = percent sulfite pulp in final product.

(4) Papergrade sulfite equations for toxics:

Pentachlorophenol (PCP) = $(0.000950x^2 - 0.0506x + 3.2)/1000$

Trichlorophenol (TCP) = $(0.00114x^2 - 0.0607x + 3.84)/1000$

Chloroform = $(0.00912x^2 - 0.485x + 30.72)/1000$

Non-continuous discharges shall not exceed the following maximum day effluent concentrations:

Pentachlorophenol - 0.025 milligrams/litre

Trichlorophenol - 0.030 milligrams/litre

Chloroform - 0.240 milligrams/litre

Zinc - 3.0 milligrams/litre

(5) BCT is not proposed at this time.

(6) New subcategory - no BPT limits.

NOTE: pH for all categories shall be within the range of 5.0 to 9.0 at all times.

APPENDIX III.

TOXIC AND NONCONVENTIONAL POLLUTANTS UNDER INVESTIGATION IN THE UNITED STATES SCREENING PROGRAM

1. *acenaphthene
2. *acrolein
3. *acrylonitrile
4. *benzene
5. *benzidine
6. *carbon tetrachloride (tetrachloromethane)

*Chlorinated Benzenes (Other than Dichlorobenzenes)

7. chlorobenzene
8. 1,2,4-trichlorobenzene
9. hexachlorobenzene

*Chlorinated Ethanes

10. 1,2-dichloroethane
11. 1,1,1-trichloroethane
12. hexachloroethane
13. 1,1-dichloroethane
14. 1,1,2-trichloroethane
15. 1,1,2,2-tetrachloroethane
16. chloroethane

*Chloroalkyl Ethers

17. bis(chloromethyl) ether
18. bis(2-chloroethyl) ether
19. 2-chloroethyl vinyl ether (mixed)

*Chlorinated Napthalene

20. 2-chloronaphthalene

*Chlorinated Phenols (Other than those listed elsewhere; includes chlorinated cresols

21. 2,4,6-trichlorophenol
22. parachlorometa cresol
23. *2-chlorophenol

24. *chloroform (trichloromethane)

*Dichlorobenzenes

25. 1,2-dichlorobenzene
26. 1,3-dichlorobenzene
27. 1,4-dichlorobenzene

*Dichlorobenzidine

28. 3,3'-dichlorobenzidine

*Dichloroethylenes

29. 1,1-dichloroethylene
30. 1,2-trans-dichloroethylene
31. *2,4-dichlorophenol

*Dichloropropane and Dichloropropene

32. 1,2-dichloropropane
33. 1,3-dichloropropylene (1,3-dichloropropene)

34. *2,4-dimenthylphenol

*Specific compounds and chemical classes as listed in the consent decree.

APPENDIX III. CON'T.

*Dinitrotoluene

35. 2,4-dinitrotoluene
36. 2,6-dinitrotoluene

37. *1,2-diphenylhydrazine
38. *ethylbenzene
39. *fluoranthene

*Haloethers (other than those listed elsewhere)

40. 4-chlorophenyl phenyl ether
41. 4-bromophenyl phenyl ether
42. bis(2-chloroisopropyl) ether
43. bis(2-chloroethoxy) methane

*Halomethanes (other than those listed elsewhere)

44. methylene chloride (dischloromethane)
45. methyl chloride (chloromethane)
46. methyl bromide (bromomethane)
47. bromoform (tribromomethane)
48. dichlorobromomethane
49. trichlorofluoromethane
50. dichlorodifluoromethane
51. chlorodibromomethane

52. *hexachlorobutadiene
53. *hexachlorocyclopentadiene
54. *isophorone
55. *naphthalene
56. *nitrobenzene

*Nitrophenols

57. 2-nitrophenol
58. 4-nitrophenol
59. *2,4-dinitrophenol
60. 4,6-dinitro-o-cresol

*Nitrosamines

61. N-nitrosodimethylamine
62. N-nitrosodiphenylamine
63. N-nitrosodi-n-propylamine

64. *pentachlorophenol
65. *phenol

Phthalate Esters

66. bis(2-ethylhexyl) phthalate
67. butyl benzyl phthalate
68. Di-n-butyl phthalate
69. di-n-octyl phthalate
70. diethyl phthalate
71. dimethyl phthalate

*Polynuclear Aromatic Hydrocarbons

72. benzo (a)anthracene (1,2-benzanthracene)
73. benzo (A)pyrene (3,4-benzopyrene)
74. 3,4-benzo fluoranthene
75. benzo (k) fluoranthene (11,12-benzo fluoranthene)
76. chrysene
77. acenapththalene
78. anthracene
79. benzo(ghi)perylene (1,12-benzoperylene)
80. fluorene
81. phenathrene
82. dibenzo (a,h) anthracene (1,2,5,6-dibenzanthracene)
83. indeno (1,2,3-cd) pyrene (2,3-0-phenylenepyrene)
84. pyrene

85. *tetrachloroethylene
86. *toluene
87. *trichloroethylene
88. *vinyl chloride (chloroethylene)

*Specific compounds and chemical classes as listed in the consent decree.

Pesticides and Metabolites

89. *aldrin
90. *dieldrin
91. *chlordane (technical mixture and metabolites)

*DDT and Metabolites

92. 4,4'-DDT
93. 4,4'-DDE (p,p'-DDE)
94. 4,4'-DDD (p,p'-TDE)

*Endosulfan and Metabolites

95. a-endosulfan-Alpha
96. b-endosulfan-Beta
97. endosulfan sulfate

*Endrin and Metabolites

98. endrin
99. endrin aldehyde

*Heptachlor and Metabolites

100. heptachlor
101. heptachlor epoxide

*Hexachlorocyclohexane (all isomers)

102. a-BHC-Alpha
103. b-BHC-Beta
104. r-BHC (lindane)-Gamma
105. g-BHC-Delta

*Polychlorinated Biphenyls (PCB's)

106. PCB-1242 (Aroclor 1242)
107. PCB-1254 (Aroclor 1254)
108. PCB-1221 (Aroclor 1221)
109. PCB-1232 (Aroclor 1232)
110. PCB-1248 (Aroclor 1248)
111. PCB-1260 (Aroclor 1260)
112. PCB-1016 (Aroclor 1016)

113. *Toxaphene

114. *Antimony (Total)
115. *Arsenic (Total)
116. *Asbestos (Fibrous)
117. *Beryllium (Total)
118. *Cadmium (Total)
119. *Chromium (Total)
120. *Copper (Total)
121. *Cyanide (Total)
122. *Lead (Total)
123. *Mercury (Total)
124. *Nickel (Total)
125. *Selenium (Total)
126. *Silver (Total)
127. *Thallium (Total)
128. *Zinc (Total)

129. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

*Specific compounds and chemical classes as listed in the consent decree.

APPENDIX III. CON'T.

Additional Compounds

130. Abietic Acid
131. Dehydroabietic Acid
132. Isopiramic Acid
133. Primaric Acid
134. Oleic Acid
135. Linoleic Acid
136. Linolenic Acid
137. 9,10-Epoxystearic Acid
138. 9,10-Dichlorostearic Acid
139. Monochlorodehydroabietic Acid
140. Dichlorodebydroabietic Acid
141. 3,4,5-Trichloroguaiacol
142. Tetrachloroguaiacol
143. Xylenes

APPENDIX IV. A LIST OF PULP AND PAPER MILLS DISCHARGING INTO THE GREAT LAKES - UNITED STATES AND CANADA - 1980

Lake Basin and Jurisdiction	Loadings in 1980 - Megagrams/Day TSS	BOD
LAKE SUPERIOR		
Wisconsin		
American Can Co., Ashland	.23	.14
Superior Fiber Products, Superior	.09	.57
Michigan		
Champion International Corp., Ontonagon	3.21	1.99
Kimberly Clark Corp., Munising	.14	.12
Ontario		
Abitibi Price: - Fine Papers - Fort William - Thunder Bay	4.89	51.1
American Can, Marathon	10.5	19.8
Domtar Packaging, Red Rock	4.2	20.9
Great Lakes Forest, Thunder Bay	14.4	102.0
Kimberly-Clark, Terrace Bay	7.4	30.0
LAKE HURON		
Michigan		
Abitibi Corp., Alpena	6.36	2.58
Fletcher Paper Co., Alpena	.09	.18
Proctor and Gamble Paper Product Co., Cheboygan	.07	0.6
Ontario		
Abitibi - Price, Sault Ste. Marie	13.5	8.6
Eddy Forest, Espanola	8.1	22.5
MacMillan Bloedell, Sturgeon Falls	6.2	42.1
Nord Fibre, North Bay	.07	.07

APPENDIX IV. CONT'D.

Lake Basin and Jurisdiction	Loadings in 1980 - Megagrams/Day TSS	BOD
LAKE MICHIGAN		
Michigan		
Allied Paper Co., Kalamazoo	.10	.20
Brown Co., Kalamazoo	.29	.23
French Paper Co., Niles	.13	.14
Manistique Pulp and Paper Co., Manistique	1.58	1.04
Mead Corp., Escanaba	5.85	3.27
Mead Corp., Otsego	.14	.15
Menasha Corp., Otsego	1.24	.94
Menominee Paper Co., Menominee	.24	.62
Packaging Corp. of America, Filer City	.45	.22
Plainwell Paper Co., Plainwell	.57	.48
Simplicity Pattern Co., Inc., Niles	.03	.10
Watervliet Paper Co., Watervliet	.28	.28
Wisconsin		
American Can Co., Green Bay	1.41	2.58
Appleton Papers, Combined Locks	.67	.62
Badger Paper, Peshtigo	.80	.84
Bergstrom Papers, Neenah	1.31	.75
Consolidated Papers, Appleton	1.55	1.25
Fort Howard, Green Bay	6.12	4.08
George Whiting, Menasha	.03	.09
Green Bay Packaging, Green Bay	.09	.43
Kerwin Paper Corporation, Appleton	.65	.50
Kimberly Clark (Lakeview), Neenah	.11	.42
Kimberly Clark (B.G.-Neenah), Neenah	.12	.06
Midtec Paper Corp, Kimberly	.65	.63
Niagara of Wisconsin Paper, Niagara	1.73	.99
Nicolet, DePere	.42	.61
Proctor and Gamble (Charmin), Green Bay	1.46	2.25
Scott Paper, Marinette	.66	.55

APPENDIX IV. CONT'D.

Lake Basin and Jurisdiction	Loadings in 1980 - Megagrams/Day TSS	BOD
LAKE MICHIGAN, CONT'D.		
Wisconsin		
Scott Paper, Oconto Falls	.20	.34
Shawano Paper, Shawano	.04	.32
Thilmany Pulp & Paper, Kaukauna	1.87	.74
Wisconsin Tissue Mills, Menasha	.37	.34
LAKE ERIE		
Michigan		
Dunn Paper Co., Port Huron	.26	.18
Port Huron Paper Co., Port Huron	.33	.27
Simplex Industries, Inc., Palmyra	.03	.06
Ohio		
Certain-Teed Corp., Milan	<.01	<.01
Chase Bag Co., Chagrin Falls	.08	.17
Tecumseh Corr. Box Co., Brecksville	.04	.07
U.S. Gypsum Co., Gypsum	.04	.03
LAKE ONTARIO		
Ontario		
Beaverwood Fibre, Thorold	.82	1.5
Domtar Construction, Thorold	.21	.3
Domtar Fine Papers, Cornwall	12.0	13.3
Domtar Fine Papers, St. Catharines	.42	.83
Domtar Packaging, Trenton	.3	2.9
Fraser Paper, Thorold	3.5	4.4
Kimberly-Clark, St. Catharines	.22	.52
Kimberly-Clark, Huntsville	*	*

*This mill employs a tertiary treatment system, accordingly, its discharges of TSS and BOD are extremely low.

Lake Basin and Jurisdiction	Loadings in 1980 - Megagrams/Day TSS	BOD
LAKE ONTARIO, CONT'D.		
Ontario		
Ontario Paper, Thorold	7.5	21.7
Strathcona Paper, Strathcona	.1	.47
Trent Valley, Glen Miller	1.2	.34
New York		
Armstrong Cork, Volney	.23	.46
Boise Cascade (Lewis Mill), Croghan	.08	.18
Boise Cascade (Latex Mill), Croghan	.09	.07
Boise Cascade, Brownville	.08	.04
Burrows, Lyonsdale	.08	.04
Burrows, Phoenix	Closed	
Continental Can, Tonawanda	Closed	
Georgia Pacific, Lyons Falls	2.48	1.38
Groveton Paper, Gouverneur	.03	.05
International Paper Co., N. Tonawanda	Closed	
Knowlton Brothers, Watertown	<.01	<.01
McIntyre Brothers, Fayetteville	.07	.04
Newton Falls Paper Co., Newton Falls	.88	.79
North End Paper, Fulton	.10	.07
Potsdam Paper, Potsdam	.19	.32
St. Lawrence Pulp and Paper, Ogdensburg	Closed Temporarily	
St. Regis, Deferiet	2.11	.50
Schoeller Technical Papers, Pulaski	.07	.17
Sealright Co., Fulton	Closed	
Simplicity Pattern, Norfolk	.08	.11
Spaulding Fibre, Tonawanda	0*	0*
U.S. Gypsum, Oakfield	.23	.12

*This mill does not discharge any organic process water into the lake.

APPENDIX V. A LIST OF PULP AND PAPER MILLS DISCHARGING INTO PUBLICLY OWNED TREATMENT WORKS (POTW) UNITED STATES AND CANADA - 1980

Jurisdiction

INDIANA

Georgia Pacific Corp., Gary
Keyes Fibre, Hammond
Owen-Corning, Mishawaka
Packaging Corporation of America, Griffith

MICHIGAN

Allied Paper Co., Kalamazoo
Brown Co., Kalamazoo
Georgia Pacific Corp., Kalamazoo
James River-Rochester Inc., Rochester
National Gypsum Co., Kalamazoo
Peninsular Paper Co., Ypsilanti
St. Regis Paper Co., Battle Creek
Scott Paper Co., Detroit
Simplex Industries, Inc., Constantine
Time Container Corp., Monroe
Union Camp, Monroe
S. D. Warren Co. (Scott Paper), Muskegon

MINNESOTA

Conwed Corp., Cloquet
Potlatch Inc., Cloquet
Superwood, Duluth

NEW YORK

Beaverboard Co., Lockport
Brownville Paper, Brownville

APPENDIX V. CONT'D.

Jurisdiction
NEW YORK, CONT'D.
Climax Manufacturing, Carthage
Crown Zellerbach, Carthage
Hammermill Paper, Oswego
Nitec, Niagara Falls
Spaulding Fibre, Tonawanda
ONTARIO
Atlantic Packaging, Scarborough
Continental Can, Toronto
Diamond National, Brantford
Dominion Cellulose, Toronto
Domtar Fine Paper, Toronto
Domtar Packaging, Mississauga
Domtar Packaging, Toronto
IKO Industries, Brampton
Rolland Paper, Scarborough
Sonocco Products, Brantford
PENNSYLVANIA
Hammermill Paper Company, Erie
WISCONSIN
Fox River Paper Co., Appleton
Gilbert Paper Co., Menasha
Kimtech Development (North), Neenah
Menasha Corp. (Paperboard), Menasha
Ponderosa Pulp Products, Oshkosh
U.S. Paper Mills (Paperboard), DePere
Wisconsin Paperboard Corp., Milwaukee